

## BMP #38b - Bioinfiltration swale (Bioretention swale)

### Targeted Pollutants

75% Sediment

30% Phosphorus



Trace metals



Bacteria



Petroleum hydrocarbons

### Physical Limits

Drainage area 5 ac

Max slope 4%

Min bedrock depth 6 feet

Min water table 3 feet

SCS soil type AB  
(examples: Avonville, Garrison,  
McGuire)

Freeze/Thaw fair

Drainage/Flood control yes

### DESCRIPTION

(Updated: July 2003)

Bioinfiltration swales are depressions created by excavation, berms or small dams placed in channels intended to infiltrate the first half-inch of storm water runoff from impervious surfaces through a grass or vegetative root zone.

Work done in Spokane County, Washington on the adjoining Spokane Valley aquifer show that infiltration of the first half-inch of storm water runoff from impervious surfaces provides treatment for approximately 90 percent of contaminant load carried in storm water. The BMP 38b design is based on treatment of a precipitation rate of 0.10 inches per hour. This is expected to treat greater than 90% of flows and the first half-inch of runoff from precipitation events in Kootenai County. The design flow will need to be adjusted for other areas based on precipitation records.

### Application and Limitations

An open basin at the ground surface can be used where sufficient open space is available. This takes advantage of existing natural surface depressions and swales on the site where a berm or a low dam could very simply create the needed area. Alternatively, the landscape can be designed to include a depressed area in which to place the basin. Road ditch areas are suited to use for bioinfiltration areas given the proper soil conditions.

A surface basin's construction involves proper soil profile modification, grading, and planting. The number, size, shape, construction, and planting of a basin should be suited to the slope, configuration and human use of the site. Runoff can be delivered through a swale, armored

flume, drop structure, or a buried culvert discharging directly to the basin floor. These structures can be designed to be consistent with the characteristics of the site.

The appropriate soil conditions for infiltration and the protection of ground water are the most important considerations limiting the use of this BMP. Planting soils should be loamy, with a clay content of less than 15 percent. The soil should contain 3-5% organic material and have a pH of 5.5 to 6.5. (Examples of appropriate soil types in Idaho are the Garrison, Avonville and McGuire soil types on the Rathdrum Prairie.) Because soils can vary tremendously over short distances, site specific testing is required to determine if the minimum infiltration rate is sufficient. If the tested infiltration rate cannot meet minimum

values, more permeable material must be imported and the soil profile must be modified to allow these swales to properly function.

As with any type of infiltration facility, bioinfiltration swales should not be used in areas with shallow aquifers. An official inventory form must be submitted to the Idaho Department of Water Resources. Contact the closest regional office for further information.

## **Design Parameters**

General design parameters for bioretention facilities include:

- Facility size 5-7% of the impervious area draining to it
- Surface area of facility less than 1 acre (0.4 hectares)
- Several small facilities rather than one large facility
- Ponding area depth limited to 6 inches (15 cm)
- Planting soil depth of 4 feet (1.2 m). Adequate nutrient removal requires a minimum of 2.5 feet (0.76 m).

The following specific design parameters given in this BMP have been developed as trial and error methods in Spokane County, Washington and Kootenai County, Idaho. A technical advisory committee for storm water design compiled this accumulated knowledge for the Rathdrum Prairie Aquifer, convened in the summer of 2000.

Any design should keep in mind, the leading failure causes for bioinfiltration swales:

1. Pre-silting during construction. This occurs generally after the contractor has roughed in the swales during the excavation phase of construction. Loose soil from the development is washed from the streets and off of building sites into the swales. This loose soil lowers the permeability to the point of swale failure, even though the original soil permeability was adequate.
2. Compaction of soils during construction. Heavy equipment run in the swale improperly can decrease swale permeability to cause failure.
3. Imported soils for landscaping. Soils imported for landscaping added to the swale decrease the swale soil permeability and cause failure.
4. Over irrigation of grass. Vegetation in the swale is irrigated excessively to the point where almost constant soil saturation is occurring and when a rainfall event does occur the infiltration rate is not adequate.

**Soils.** Infiltration should be measured using ASTM D 5126 single ring infiltrometer test, but this is a local option. Soil infiltration capacity must be a minimum 0.5 inches (1.3 cm) per hour for the life of the swale. The maximum infiltration rate is 3.0 inches (7.5 cm) per hour. A higher maximum infiltration rate may be acceptable if an adequate vegetative cover can be maintained without excessive irrigation. Infiltration rate must be tested if the swale has the appearance of non-compliance with the required infiltration rate. This generally shows up as prolonged ponding around the dry well intake.

**Slopes.** The bioinfiltration swale should have slopes that do not result in erosive velocities for the design storm. This is usually less than or equal to 4% unless check dams (BMP #22) are installed.

**Water Velocity.** Treated water velocity as it enters and flows across the swale must not exceed the erosional velocity of 0.3 ft/s.

**Inflow Volume.** Maximum volume per double depth dry well is 1 cfs (0.03 m<sup>3</sup>/sec) or 0.3 cfs (0.008 m<sup>3</sup>/sec) for a single depth.

**Drywell Intake Height.** Flat bottom swale. 6 inches (15 cm) above the swale bottom elevation.

Sloping swale. The drainage area from the last curb cut to the drywell determines the drywell height in the sloping swale. The first half of the runoff from this impervious roadway or parking lot area must be ponded and treated. Final drywell grade must be below grade of roadway surface.

**Design Storm Treatment Area.** The sloped swale design storm for the Rathdrum Prairie Aquifer (90 % of storm water treated) is 0.1 inch (0.25 cm) per hour intensity (Dobler, 2000). The area of the swale is determined by matching the infiltrative capacity with the rate of flow into the swale. This calculation can be done incrementally with the Manning's flow equation (Chow, 1959 page 111). An acceptable method for calculating inflow into the swale from the impervious area is the Rational Method (Soil Conservation service). None of the first half of storm runoff should reach the dry well prior to infiltration for the design to be acceptable. Figure 2 is an illustration of the sloped swale and accompanying dry well.

The county or municipality where the facility is located should provide the maximum design storm for the facility. Do not confuse the requirements for storm water treatment in either of these methods with the need to control and dispose of extreme storm flows.

**Vegetative Cover.** The swale and associated side slopes must be vegetated with broad leaf grass to a level as high as expected flow depth. Vegetation should not be allowed to grow more than 6 inches (15 cm). Trees and brushy buffer strips may also be used to slow water velocities and enhance infiltration.

**Buildings.** Swales should be a minimum of 100 feet (30.5 m) up slope and 20 feet (6.1 m) down slope from any building.

## Construction Guidelines

**Construction Schedule.** The sequence of various phases of basin construction should be coordinated with the overall project construction schedule. A program should schedule rough excavation of the swale with the rough grading phase of the project to permit use of the fill in earthwork areas. The partially excavated basin may serve as a temporary sediment trap or pond in order to assist in erosion and sediment control during construction. However, swales near the final stages of excavation should never be used prematurely for runoff disposal. Drainage from untreated, freshly constructed slopes within the watershed area would load the newly formed basin with a heavy concentration of fine sediment. This could seriously impair the natural infiltration characteristics of the swale floor. Final grade of a bioinfiltration swale should not be attained until after its use as a sediment control basin is completed.

Specifications for swale construction should state the earliest point in construction progress when storm drainage may be directed to the swales, and the means by which this delay in use should be accomplished. Due to the wide variety of conditions encountered among projects, each should be separately evaluated in order to postpone use as long as reasonably possible.

**Excavation.** Initial swale excavation should be carried to within 1 foot of the final elevation of the swale floor. Final excavation to the finished grade should be deferred until all disturbed areas on the site have

been stabilized or protected. The final phase of excavation should remove all accumulated sediment. The associated dry well should be installed during the final phase of excavation. Relatively light tracked equipment is recommended for this operation to avoid compaction of the swale floor. An option to maintain infiltration rates is to over excavate the swale and fill with permeable soils (see design infiltration rates). After the final grading is completed, the swale floor should be scarified to provide a well-aerated, highly porous surface texture.

**Infiltration Test.** A ring infiltrometer test (ASTM D5126) should be conducted (a local option) after final grading and the determined rate of infiltration must be at a minimum 3.0 inches (10 cm) per hour. The maximum allowable rate is 2.5 inches (6.4 cm) per hour, unless it can be shown that a satisfactory vegetative cover can be maintained without excessive irrigation. The local permitting agency must provide this inspection. Should the swale not meet the minimum infiltration rate of 0.5 inches (1.3 cm) per hour, more permeable material must be brought in and incorporated (or replace) the first 6 to 10 inches (15 to 25 cm) of the existing material and the infiltration test redone. If the soil cannot be treated to reach the minimum infiltration rate then an alternative design must be made.

**Vegetation.** A healthy stand of broad leaf grass should be established on the swale floor and slopes. This vegetation will not only prevent erosion and sloughing, but will also provide a natural means of maintaining infiltration rates and will provide the pollution removal. Erosion protection of inflow points to the basin should also be provided (e.g., riprap, flow spreaders, energy dissipators). Removal of accumulated sediment is a problem only at the basin floor. Little maintenance is normally required to maintain the infiltration capacity of side slope areas.

## **Maintenance**

**Goal.** To ensure that the swale operates as designed by maintaining the infiltration and treatment capabilities of the physical and biological portions of the system.

**Access.** Provide enough access space for maintenance activities. Check with local permitting authority to determine if a dedicated maintenance easement is required for the swale.

**Inspection.** When swales are first placed into use they should be inspected on a monthly basis, and more frequently if a large storm occurs between that schedule. During the period October 15 through April 15 inspections should be conducted monthly. Thereafter, once it is determined that the basin is functioning in a satisfactory manner and there are no potential sediment problems, inspections can be reduced to a semi-annual basis with additional inspections following the occurrence of a large storm. Inspectors should check for functional inlet, erosion, condition of vegetation, ponded water, disposal of other waste in the swale or drywell, and conformance with original design.

**Sediment Control.** The swale should be designed with maintenance in mind. Access should be provided for vehicles to easily maintain the swale. Grass bottoms in bioinfiltration swales seldom need replacement since grass serves as a good filter material. If silty water is allowed to trickle through the turf, most of the suspended material is strained out within a few yards of surface travel. Well-established turf on a swale floor will grow up through sediment deposits forming a porous turf and preventing the formation of an impenetrable layer. Grass planted on swale side slopes will prevent erosion.

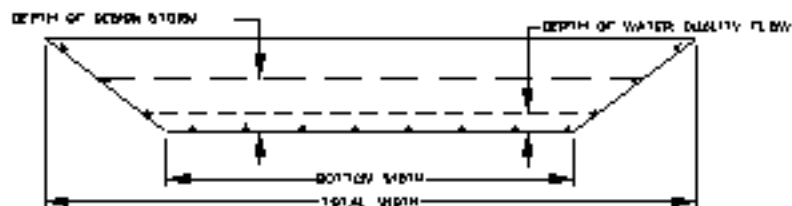
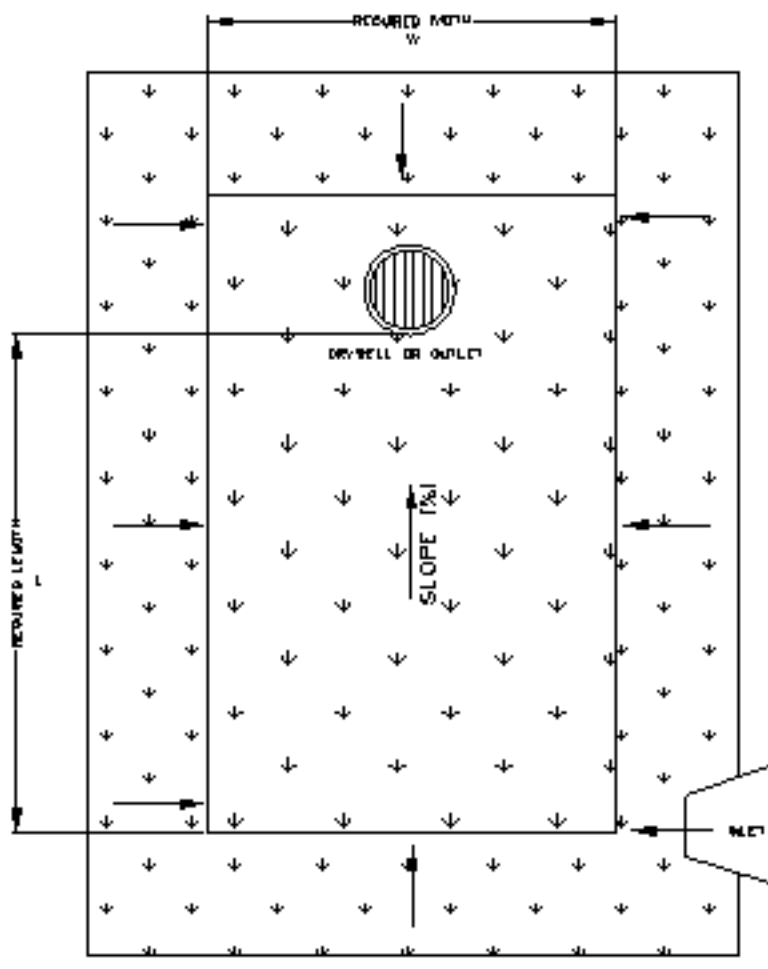
**Vegetation Maintenance.** Maintenance of vegetation established on the swale floor and side slopes is necessary in order to promote dense turf with extensive root growth which enhances infiltration, prevents erosion and consequent sedimentation, and prevents invasive weed growth. Bare spots should be immediately stabilized and re-vegetated.

The use of low growing, stoloniferous (grasses that spread by stolon rather than seed) grasses will permit long intervals between mowings. Mowing at regular intervals is necessary to keep the grass less than 6 inches (15 cm) long. Fertilizers should be applied only as necessary and in limited amounts to avoid contributing to the pollution problems, that the swale is intended to solve. Excessive irrigation should be avoided as saturated soils have a lower infiltration capacity than dry soils and the intent of the swale is to infiltrate water from the drainage area.

### **ADDITIONAL INFORMATION**

This swale BMP for the Rathdrum Prairie Aquifer was created by a Technical Advisory Committee (TAC) convened in June 2000. The BMP was completed in December 2000 for inclusion into the DEQ Catalog of *Storm Water Best Management Practices*.

DEQ would like to acknowledge and thank the following individuals for serving on the TAC: Gordon Dobler, City of Coeur d'Alene; Stan Miller, Spokane County; Mike Hartz, ITD; Bill Melvin, Post Falls; Ed Hale and Rick Barlow, PHD; Paul Klatt, J-U-B; Dave LePard, IDWR; Jack Smetana, Frame & Smetana; Rand Wichman, Kootenai County; John Mueller, Hatchmueller Consultants; Gary Gaffney, June Bergquist and Brian Painter (Chair), DEQ. In addition, DEQ would like to thank Calvin Terrada, EPA; Mark Slifka, Bob Haynes and Mike Piechowski, IDWR; and David Karsann, ITD for attending the first meeting to help decide the need for a Technical Advisory Committee.



### TRAPEZOIDAL CROSS SECTION

Figure 1 - Diagram of a grassed infiltration area showing characteristics used in design equations.